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(Article begins on next page)

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Competition and Pass-Through: Evidence from Isolated Markets[1]

Christos Genakos[2] and Mario Pagliero[3]

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Abstract

We measure how pass-through varies with competition in isolated oligopolistic markets with captive consumers. Using daily pricing data from gas stations on small Greek islands, we study how unanticipated and exogenous changes in excise duties (which vary across different petroleum products) are passed through to consumers in markets with different numbers of retailers. We find that pass-through increases from 0.4 in monopoly markets to 1 in markets with four or more competitors and remains constant thereafter. Moreover, the speed of price adjustment is about 60% higher in more competitive markets. Finally, we show that geographic market definitions based on arbitrary measures of distance across sellers, often used by researchers and competition authorities, result in significant overestimation of the pass-through when the number of competitors is small.

JEL: H22, L1

Keywords: Pass-through; Tax incidence; Gasoline; Market structure; Competition; Greek islands.

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[2] Cambridge Judge Business School, AUEB, CEP, and CEPR, E: c.genakos@jbs.cam.ac.uk
[3] University of Turin, Collegio Carlo Alberto, and CEPR, E: mario.pagliero@unito.it

1. Introduction

A fundamental issue in economics is how firms pass cost shocks (taxes, exchange rates, input prices) through to prices. The incidence and pass-through of taxation are classic public policy concerns (Fullerton and Metcalf, 2002). The pass-through of exchange rates and tariffs has important repercussions on firm productivity and international trade (De Loecker and Koujianou-Goldberg, 2014). Moreover, the pass-through of input prices is relevant to the analysis of oligopolistic markets, price discrimination (Aguirre, Cowan and Vickers, 2010), and merger analysis (Jaffe and Weil, 2013). Finally, the cost pass-through is also relevant to the policy debate (Genakos, Grey and Ritz, 2020) in many industries, such as the health (Cabral, Geruso and Mahoney, 2015) and energy sectors (Fabra and Reguant, 2014).

Theoretical analysis shows that competition is a key determinant of pass-through (Weyl and Fabinger, 2013). As for the empirical analysis, there is a well-established line of research exploiting plausibly exogenous variability in costs to infer the magnitude of pass-through.[4] However, there is little evidence on the relation between competition and pass-through. In empirical studies, competition is generally measured by the number of competitors located within a given geographical area around each firm. Variability in the number of close competitors captures some important aspects of competition, but does not guarantee that there are no significant substitution effects beyond the selected geographical area. For example, some consumers may commute across geographical markets for work or family reasons, hence generating substitution effects across geographically distant markets. Although market structure

[4] Such variability may come from changes in sales taxes (Barzel, 1976; Poterba, 1996; Besley and Rosen, 1998; Marion and Muehlegger, 2011), exchange rate fluctuations (Campa and Goldberg, 2005; Gopinath, Gourinchas, Hsieh and Li, 2011), or changes in input prices (Borenstein, Cameron and Gilbert, 1997; Genesove and Mullin, 1998; Nakamura and Zerom, 2010; Miller, Osborne and Sheu, 2017).

is recognized as an endogenous outcome, it is generally difficult to find valid instruments for competition.

We measure how pass-through varies with competition in isolated oligopolistic markets of different sizes. Our data come from the retail market for petroleum products (gasoline, unleaded gasoline, diesel, heating oil) on the many small islands Greece is known for. Some of these islands are so small that they have just a single gas station, while others have two, three, or more. The naturally occurring variability in island size provides an exogenous source of variability in the level of competition. Islands clearly define local markets, as substitution effects between islands are zero.[5] The logic of this approach is similar to that of Bresnahan and Reiss (1991), who study entry in geographically isolated oligopolistic markets.

Along with this unique setting, we take advantage of significant policy changes made by the Greek government when, at the beginning of the financial crisis in 2010, they increased the excise duty on petroleum products three times. The increments were large and unannounced and provide us with an ideal exogenous shock for estimating the pass-through to retail prices. For political reasons, heating oil was excluded from the excise hikes, as it was considered a necessity good.

Using daily gas station data, we study how the pass-through of the excise duty tax varied across markets with different numbers of competitors, while using heating oil as a control group. Thus, we can account for unobserved heterogeneity across islands and gas stations, and control for the daily aggregate price fluctuations of petroleum products using the control group. We find four main results. First, the response to cost shocks is rapid, with an average pass-through of 0.71 after 10 days from an excise duty change. Second, pass-through increases significantly with the number of competitors, and the relation between competition and pass-through is nonlinear. On average,

[5] Refueling a car by travelling to a different island is prohibitively expensive, and privately importing fuel in tanks or similar containers is dangerous and illegal.

the pass-through is 0.43 on monopolistic islands and grows to about 1 on islands with four or more competitors. Third, we find that price adjustments are larger and occur more quickly in more competitive markets, leading to faster pass-through in more competitive markets. Fourth, we find that using geographical market definitions based on distance across sellers (rather than the island market definition) results in overestimation of pass-through in highly concentrated markets.

Our results contribute to the literature on the transmission of cost shocks to prices, whose ultimate objective is to understand the strength of nominal rigidities and the impact of fiscal, monetary, and exchange rate policy. Existing evidence on the impact of competition on pass-through is scarce and somewhat mixed. For example, Miller, Osborne and Sheu (2016) find that increasing competition reduces pass-through in a market in which the pass-through is above unity.[6] Cabral, Geruso and Mahoney (2018) study the pass-through of government subsidies to premiums of Medicare Advantage plans and find evidence of larger pass-through in more competitive markets, with pass-through estimates ranging between 13% and 74%. Alm, Sennoga and Skidmore (2009) find a somewhat lower pass-through in rural than in urban gasoline markets, which might be related to the different competitive environments. In contrast, Doyle and Samphantharak (2008) and Stolper (2018) find that greater brand concentration and market power are associated with larger pass-through rates in the gasoline market.

Our finding of quick response to cost shocks is in line with the results of Bonadio, Fisher and Sauré (2016), who show a two-week adjustment period after a large exchange rate shock. Our results imply a positive correlation between pass-through and frequency of price adjustments across markets with different levels of competition, which is in line with the results of Gopinath

[6] This is consistent with convergence towards a unit pass-through as competition increases. Other studies have found evidence of pass-through larger than one (see, for example, Besley and Rosen 1999, Hanson and Sullivan 2009, Bonnet and Réquillart 2013), which is entirely possible according to theory (see, Section 2).

and Itskhoki (2010). Our results are also related to the literature on the nonlinear effects of competition on firm behavior (Bresnahan and Reiss, 1991) by showing that the pass-through quickly converges to competitive levels as the number of competitors grows. Finally, the paper contributes to the empirical literature on the estimation of cost pass-through and the analysis of competition in geographical markets (Houde, 2012).

2. Theoretical background

Economic theory provides some general results on how competition and other variables interact in determining the level of pass-through. Following the conduct parameter approach of Genesove and Mullin (1998), Weyl and Fabinger (2013) obtain an equation for the pass-through in oligopolistic markets with n symmetrically differentiated firms. Denoting by $\epsilon_D = -\frac{p}{qp'}$ the elasticity of demand, they describe the solution to the firm maximization problem by a conduct parameter $\frac{p-mc(q)}{p}\epsilon_D = \theta$, where $mc(q)$ is the marginal cost. θ captures the intensity of the competition among firms ($\theta = 0$ in a competitive market and $\theta = 1$ in a monopolistic market). Independently of the specific model considered, the impact of an increase in marginal cost (i.e., the pass-through) on the equilibrium price is

$$\rho = \frac{1}{1+\frac{\theta}{\epsilon_\theta}+\frac{\epsilon_D-\theta}{\epsilon_S}+\frac{\theta}{\epsilon_{ms}}}. \quad (1)$$

The pass-through ρ depends on the conduct parameter θ and how it varies as the quantity produced changes ($\epsilon_\theta = \frac{\theta}{q\frac{d\theta}{dq}}$), but also on the determinants of the elasticity of demand ϵ_D, the elasticity of the inverse marginal cost curve ϵ_S (the elasticity of supply), and the curvature of the demand function ϵ_{ms}.[7] In general, the sign and magnitude of the pass-through is ambiguous. The sign of the effect of an increase in the conduct parameter on the pass-through can be either positive or negative.

The expression for ρ greatly simplifies in some special cases, highlighting the role of the different elements in the denominator of equation (1). The ratio $\frac{\epsilon_D-\theta}{\epsilon_S}$ links demand and supply elasticity and pass-through.[8] This ratio is equal to zero if the marginal cost is constant. As we will argue in Section 3, it is realistic to assume that marginal cost is constant at the firm level, at least in the short run, and for the range of quantities typically sold by gas stations in our sample. This suggests that demand heterogeneity is unlikely to play a big role in our application through the ratio $\frac{\epsilon_D-\theta}{\epsilon_S}$. Still, heterogeneity in demand curvature may be relevant through the ratio $\frac{\theta}{\epsilon_{ms}}$.

A second interesting special case is when θ is constant. If θ is constant, then the term $\frac{\theta}{\epsilon_\theta}$ is also equal to 0. The conduct parameter θ is a constant in a number of prominent models. For example, θ is equal to 1 in monopoly, equal to 0 in perfect competition and in the Bertrand model, equal to $\frac{1}{n}$ in the Cournot model.[9] The conduct parameter is assumed to be a constant in most empirical applications based on the conduct parameter approach.

Finally, an important determinant of the pass-through is the demand curvature ϵ_{ms}. Many empirical studies are based on linear demand specifications, directly implying that $\epsilon_{ms} = 1$.

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[7] $\epsilon_{ms} = \frac{ms}{ms'q}$, where ms is the negative of the marginal consumer surplus ($ms = -p'q$). ϵ_{ms} measures the curvature of the log of demand (Fabinger and Weyl 2012). If demand is linear then $\epsilon_{ms} = 1$, if concave $\epsilon_{ms} < 1$, if convex $\epsilon_{ms} > 1$ (and the opposite is also true).

[8] Note that if $\theta = 0$, then $\rho = \frac{1}{1+(\epsilon_D/\epsilon_S)}$, which is the classic formula for tax pass-through in perfect competition.

[9] The relation between the conduct parameter and the number of firms *n* illustrates the sense in which an increase in the number of firms leads to greater competition. In empirical papers, which typically deal with specific industries, the number of firms is often used as a proxy for the intensity of competition.

However, it is not uncommon to assume different demand specifications that imply different curvature, although there is little guidance in the literature on the sign and magnitude of ϵ_{ms}.

If the marginal cost were constant, θ were constant, and demand were linear, then $\rho = \frac{1}{1+\theta}$ and an increase in the conduct parameter (less competition) would lead to lower pass-through.[10] The first assumption is met in several industries and is realistic in our application. The second is often considered a reasonable simplification in empirical studies, in not putting restrictions on the intensity of competition. However, the third is difficult to justify without specific evidence on the second derivative of the demand function. Hence, in general, the impact of an increase in competition on pass-through remains largely an empirical issue.

3. Industry background and data

Oil is the main energy source in Greece. In 2010, it accounted for 52% of the country's total primary energy supply, which is substantially higher than the average in most other advanced countries (36% in 2010).[11] Two companies operate in the Greek refining industry: Hellenic Petroleum has three refineries, while Motor Oil Hellas has one. Hellenic Petroleum controls 72% of the wholesale market.[12] There are ten oil terminals in Greece, seven of which are in the Attica area (Athens) and three in the Salonica area (north). In 2010, there were 20 fuel trade companies operating in the retail market, the largest of which were EKO (a subsidiary of Hellenic Petroleum), Shell, BP, Avin Oil (100% subsidiary of Motor Oil), and Jet Oil. The marginal cost of petroleum

[10] Moreover, in this special case, the relation between pass-through and θ can be inverted, so estimating the pass-through provides information about the conduct parameter.
[11] International Energy Agency, Energy Policies of IEA Countries, 2011 review.
[12] The Greek government owns 35.5% of Hellenic Petroleum, but no shares in Motor Oil Hellas.

products depends on long-term contracts between gas stations and trade companies. Within the observed range of quantities sold, the marginal cost of gas stations is reasonably constant. EU member states are required to impose a minimum array of energy taxes, but each member state has significant freedom in setting tax rates.[13] There are two main taxes that are imposed on energy products: excise duties, which is a unit tax rate (€-cents per liter), and the Value Added Tax (VAT), which is a percentage tax. The retail price is determined as $P_{retail} = (P_{refinery} + taxes\&fees + margins)(1 + VAT)$. In this paper, we focus on the impact of changes in excise duties on prices, which are reported net of VAT.

In 2010, the inability of the Greek government to borrow new funds from the international markets led to financial support from euro-area member states and the International Monetary Fund. One of the first measures taken by the Greek government to increase tax revenues was to increase excise duties on fuel. Excise duties on fuel were raised three times in 2010. Each of these three tax changes was announced and implemented the day after the decision was made, as typically happens in order to reduce opportunities for arbitrage. Table 1 shows that the tax changes were significant (between 8% and 29%) and different across products. Remarkably, excise duties for heating oil remained unchanged.[14]

3.1. Data and measurement of competition

We combined several datasets for our analysis. First, we obtained daily station-level retail prices during 2010 for a sample of gas stations located on Greek islands. The data contains information

[13] EU guideline 2003/96/EU.
[14] Heating oil is chemically identical to diesel (although colored differently to prevent substitution) and is sold by the same gasoline stations throughout the country. A lower excise duty is applied to it, as it is considered a necessity, since the vast majority of households use heating oil rather than gas during the winter months. Obviously, it is illegal to sell and use heating oil for transportation and the prohibition is actively enforced.

on five different gasoline products: unleaded 95, unleaded 100, super (or leaded gasoline), diesel, and heating oil. The data on prices was officially collected by the Greek Ministry of Development and Competitiveness (2018) through a reporting system, which required managers of each petrol station to record retail prices daily. The purpose of this system was to facilitate comparison and reduce search costs for consumers.

Second, we obtained socioeconomic (e.g., education, income, number of tourist arrivals) and geographic (size, distance from Piraeus[15], distance from mainland, number of ports and airports etc.) characteristics of each island from the Hellenic Statistical Authority (2010). Third, we measured the number of gas stations operating in each island using independent information from Yellow Pages (2018) and company reports.[16] Finally, using Google maps (2018), we geo-located each gas station and verified whether each station was offering any additional services (such as shop, carwash, tire repairs etc).

We focus on the 33 smallest islands, with fewer than 8 stations (Table A1 in the Appendix), and a period of 10 days before and after each excise duty change described in Table 1. The price reporting system provides more than 10,000 observations at the product-station level for 58 gas stations (or 61% of all stations) located on 26 islands. We test the representativeness of the final sample of gas stations and cannot reject the null hypothesis of no difference in mean characteristics between stations in and out of the sample.[17] Table 2 reports summary statistics.

[15] The primary distribution center for gasoline products in Greece

[16] Industry reports and Yellow Pages data for different years show that entry and exit was essentially zero in this period.

[17] For the two groups, we compute the average number of competitors on the island, average island population, size (Km^2), number of tourist arrivals for that year, educational attainment of the island population, number of ports, number of airports, and station characteristics such as the presence of a shop, carwash, tire repair facilities. The results are reported in Table A2 in the Appendix.

There are two main reasons for focusing on small islands. First, small islands have a small population and are physically small. The median island in our sample has about 2,500 inhabitants, and it is just 74 Km^2 (Table 2). Hence, consumers plausibly have close to perfect information about each station' prices and can reach all of them quite easily. Second, the number of competitors on a given island is the result of an entry game. In equilibrium, larger islands can sustain more competitors, each of them enjoying smaller markups. Bresnahan and Reiss (1991) find that competitive conduct changes quickly as the number of incumbents increases. They find that the most variation in conduct occurs with the entry of the second or third firm. Hence, selecting islands with fewer than 8 firms provides a sufficiently large range to capture the main effects of competition.

Arbitrage across islands is basically impossible, as the cost of transporting a car by ferry outweighs the potential savings in fuel cost. The set of islands considered in this paper generally host only small fishing boats, which are too slow to make it profitable to travel to a different island for refueling. Larger vessels (commercial ships or larger fishing boats) stop and refuel in larger ports with more facilities and possibly connections with the mainland.

Different measures of competition are possible for islands with more than one gas station. Having geo-located each station, we also compute measures of competition based on the number of competitors within a 3 Km driving distance from each station, a 3 Km radius, or alternatively, a 10-minute driving time, thus taking into consideration not just the distance but also the underlying geography of the island. These are conventional methods of measuring competition when there is no natural boundary across markets. In Section 5.4, we compare the results obtained using these alternative measures. Finally, there is very little to no brand concentration at the island level. In all islands in our sample, gas stations are either franchisees of different brands (dealer operated, not company owned) or independently owned.[18] Hence, the number of gas stations on each island realistically captures the number of competitors on that island.

Islands vary in size and number of gas stations. Figure 1, panel A shows that the larger the island (either in terms of land area or population), the larger the number of stations. On average, monopolies have about 1,100 inhabitants, while islands with 7 stations have about 9,800. In terms of physical size, monopolies are on average 54 Km^2, while islands with 7 stations are about 110 Km^2. Prices vary significantly across islands. For example, Figure 1, panel B shows the distribution of the average price for diesel and heating oil across islands.[19] On average, prices tend to fall as the number of competitors increases. Finally, Figure 1 panel C shows the negative correlation between island size and prices. Taken together, Figure 1 shows that larger islands tend to support more competitive markets, thus leading to lower prices. Gas stations on small islands tend to change prices less frequently than on the mainland. In our sample, a station adjusts the price of a product on average every 5 days throughout 2010.

4. Identification and empirical methodology

We use a difference in difference approach, and we start by estimating the following model:

$$P_{kist} = \beta_0 + \rho Tax_{kt} + \beta_{ks} + \beta_t + e_{kist} \quad (1)$$

where P_{kist} denotes the retail price of product k, on island i, in gas station s, on day $t \in \{\tau - 1, \tau + \delta\}$, where τ is the date of each of the three excise duty changes and $\delta = 1, \dots, 10$ is the length of the adjustment period considered. Tax_{kt} is the excise duty, and the coefficient ρ captures the tax pass-through. Finally, the model includes product-gas station and day fixed effects. This econometric approach follows a long literature on difference in difference estimators and is based

[18] Our results will not be affected by the type of gas station and the type of contract.
[19] The range of prices in Figure 3 is about €0.15 for both diesel and heating oil.

on the comparison of prices on two different dates (before and after the policy change) for a treatment (gasoline and diesel) and a control group (heating oil).[20]

We then focus on the interaction between taxes and competition and estimate the model:

$$P_{kist} = \beta_0 + \rho(n_i, Z_i)Tax_{kt} + \beta_{ks} + \beta_t + e_{kist} \quad (2)$$

where the pass-through $\rho(n_i, Z_i)$ is a linear function $\rho(n_i, Z_i) = \rho_0 + \rho_1 n_i + \rho_2 Z_i$ of the number of competitors n_i and other island specific characteristics Z_i. Alternatively, the relation between pass-through ρ and number of stations j can be non-parametrically estimated replacing $\rho(n_i) = \sum_j \rho_j I(n_i = j)$, where I is an indicator variable for each observed number of gas stations.

The identifying assumption is $E(e_{kist}|X) = 0$, where X is the matrix of all covariates. This OLS condition is reasonably met in our difference in difference framework. In fact, the tax increase was not anticipated and the price of the different petroleum products tended to follow the same trend before the policy changes (Figure A1). In summary, the differential changes in excise duties across products (Table 1) provide identification of the tax pass-through, while fixed effects capture island- and station-specific characteristics as well as the macroeconomic shocks that affected the whole economy, while the control group accounts for aggregate changes in the prices of petroleum products.

Following Ashenfelter et al. (2013), we conduct two tests of the parallel trend assumption. First, we estimate by OLS the equation

$$P_{kist} = \beta_0 + \gamma Trend_t + \gamma_T Trend_t \times Treat + \beta_k + \beta_s + e_{kist} \quad (3)$$

[20] Early applications of this methodology are found in Ashenfelter and Card (1985), Card (1992), and Card and Krueger (1994, 2000); more recent applications in industrial economics include, for example, Ashenfelter et al. (2013) and Genakos, Koutroumpis and Pagliero (2018).

where P_{kist} denotes the retail price of product k, on island i, in gas station s, on day t and $Treat$ is an indicator variable for products in the treatment group (diesel, gasoline, unleaded gasoline). We separately estimate (3) using data for the 10 days before each excise duty change. We then test and cannot reject the null hypothesis that the coefficient γ_T is equal to zero at the 5 percent confidence level (Table A3). We also replace the treatment indicator with product specific dummies and test the difference in trends between pairs of products. Again, we cannot reject the null hypothesis of parallel trends across products at the 5 percent confidence level (Table A3).

Second, we replace the trend variable in equation (3) with more flexible period-specific dummies β_t We also replace the interaction of trend and the treatment group indicator with $\beta_t \times Treat$ and then test the null hypothesis that the coefficients of the period-specific interactions are all equal to zero (individually and jointly). Even with this more flexible specification, we cannot reject the null hypothesis of parallel trends at the 5 percent confidence level (Table A4).[21]

Although variables in Z capture the potential effect of other observed island characteristics on pass-through, in Section 5.2 we will also report IV estimates of model (2), where exogenous variability in market size is used to estimate the impact of the number of competitors on pass-through. Following the literature on equilibrium entry in oligopoly markets (Bresnahan and Reiss, 1991; Berry, 1992; Mazzeo, 2002; Toivanen and Waterson, 2005), the rationale for the IV approach is that market size is a crucial determinant of entry and competition, while it is arguably uncorrelated with unobservable determinants of the pass-through (such as demand convexity). Hence, the IV approach assumes that market size can be excluded from Z, while being correlated

[21] We also estimate these specifications using longer windows for tax change 1 and 3. The results are not significantly affected.

with measures of competition. This second assumption can be tested, and it is verified in our results described in the next section.

5. Empirical results

5.1. The estimated pass-through

Figure 2 shows the average price difference between treated (diesel, unleaded 95, unleaded 100 and super) and control (heating oil) products for ten days before and after each change in excise duty tax. The solid lines represent linear regressions separately estimated before and after the tax changes. Figure A2 in the appendix plots similar graphs separately for each product and tax change. There is a significant jump corresponding to the event date. Moreover, prices tend to increase during the days following the tax changes as stations progressively adjust their prices during this period.[22] On average, 59% of product-station specific prices are adjusted within three days, 88% within 7 days, and 94% within 10 days of the tax change.

The average pass-through on a given date depends on two margins. The extensive margin is the number of stations having adjusted their price by a given date. The intensive margin is the size of the price increase for stations actually changing their prices. Accordingly, we can use equations (1) and (2) to estimate the "average" pass-through or the "conditional" pass-through ("conditional on starting to adjust"), using respectively all the data or only the data for firms that have changed their prices at least once by a given date. For long enough adjustment periods, the two definitions coincide, as all stations have adjusted their prices. However, for shorter adjustment periods, the two definitions might substantially differ. We start by reporting results for the conditional and

[22] There are no significant changes in the price of heating oil around the changes in excise duties (see Figure A3 in the appendix).

average pass-through for a 10-day adjustment period and, in Section 5.3, we will compare the conditional and average pass-through for shorter adjustment periods. The 10-day adjustment period is chosen so that it is close enough to the change in excise duty, but is also long enough for almost all of the gas station to have changed their prices.[23]

Table 3 reports the estimated coefficients of model (1). Columns 1-4 report the conditional pass-through and columns 5-8 the average pass-through for each tax change separately and pooling the data. The conditional pass-through is 0.77 (column 4) and the average pass-through 0.71 (column 8), with standard errors of about 0.1.

Although excise duty changes vary significantly across products (Table 1), when we interact Tax_{kt} with product dummies we cannot detect any significant difference in pass-through across products.[24] The estimated pass-through is slightly smaller but within the range of the unit pass-through estimated by Marion and Muehlegger (2011), Chouinard and Perloff (2007), Doyle and Samphantharak (2008), Alm, Sennoga and Skidmore (2009) for US state taxes on petroleum products and by Poterba (1996) for sales taxes on clothing. This suggests that the market for petroleum products in our sample of islands does not operate very differently from other markets studied in the literature, which is important for the external validity of our results. The slightly lower value of pass-through in our case is likely related to the fact that many gas stations in our data have a significant degree of market power. It is this topic that we explore next.

[23] The likely cause of delayed price adjustments is the slow process of restocking gas stations in relatively remote areas. Restocking is done by ships that leave from Piraeus (the main port near Athens) and follow a predetermined route across the Aegean Sea. This process is determined by the geographical dispersion of islands in the Aegean Sea and is independent of the excise duty changes and the size of the island (or other observable characteristics).

[24] We also find that the pass through is not significantly different for franchisees and independent gas stations.

5.2. Pass-through and competition

Table 4, column 1 reports the results of model (2), allowing for the interaction between tax changes and number of competitors. In column 2, we add controls for the interaction of excise duty changes and island characteristics, such as income, education, number of ports and airports, distance from Piraeus and number of tourist arrivals. The conditional and average pass-through significantly increase with competition. Column 4 shows that the relation between competition and pass-through is concave. This result is robust controlling for interactions of excise duty changes and covariates (column 5).[25] Table 4, columns 3 and 6 report the IV estimates, where the instruments are island population and its square.[26] First stage results (reported in Table A9 in the appendix) are highly significant, showing a strong correlation between market size and number of competitors. Overall, the impact of competition on pass-through is positive and decreasing as the number of competitors grows.

The non-linear relation between competition and pass-through is more clearly described in Figure 3, which shows the results of a non-parametric specification for the conditional pass-through (reported in Table 7, column 1). The pass-through is about 0.44 in monopoly islands and increases up to about 1 in islands with four competitors. The relation between pass-through and number of competitors is flat thereafter. Table A10 in the appendix reports the corresponding results for the average pass-through. The quick convergence to a unit pass-through is in line with the results of Bresnahan and Reiss (1991) that show that entry thresholds converge quite quickly; in other words, after three or four firms, an additional entrant does not affect competition much.

[25] Table A5-A8 in the appendix provide results introducing interactions one by one.
[26] Results are robust using as instrument island size.

Note that the estimated pass-through for monopoly islands is not significantly different from the 0.5 pass-through predicted by a monopoly model with linear demand.

5.3. Pass-through and speed of adjustment

The results shown in Tables 3 and 4 are obtained with a 10-day adjustment period. Table 5, reports the estimated average and conditional pass-through for different adjustment periods. Shorter adjustment periods imply a lower average pass-through, as stations progressively adjust their prices. Figure 4 shows that the average pass-through converges to the conditional pass-through. The conditional pass-through does not significantly depend on the length of the adjustment period (Table 5, column 2). The speed of convergence of the average and the conditional pass-through is in line with the relatively fast exchange rate pass-through measured by Bonadio, Fischer and Sauré (2016). Still, the speed of adjustment in our data is slower than that observed in other studies of the gasoline market (for example, Knittel, Meiselman and Stock, 2016). This can be partly explained by some specificities of our sample. In particular, the average pass-through in our sample can be affected by the lower frequency of restocking of gas stations on islands (relative to stations on the mainland).[27]

Does the speed of adjustment depend on competition? This is an important question, as it relates to understanding how quickly prices adjust to cost shocks in the economy. In imperfectly competitive markets, we cannot expect an equal speed of adjustment in markets with different level of competition (Gopinath and Itskhoki, 2010). We split the islands into two groups: those with 1 to 3 competitors ("low competition") and those with 4 or more competitors ("high competition"). Table 6 and Figure 5 report the average and the conditional pass-through for the

[27] Using a probit model, we find that the probability of a price change is not systematically related to any island characteristic such as size, population, or distance from Piraeus.

two groups for different adjustment periods. The average pass-through is significantly higher for islands with more competitors. At $t + 1$, the pass-through in more competitive markets is about 0.16 higher (about double) than in less competitive markets. At $t + 10$, the pass-through in more competitive markets is about 0.3 (or 60%) higher. The conditional pass-through is stable over time and significantly larger in more competitive markets. Finally, Figure 6 shows the cumulative frequency of price changes for the two groups and provides direct evidence that stations in more competitive markets react more quickly to changes in excise duties.[28] Hence, more competitive markets adjust faster to cost shocks, partly because the conditional pass-through is larger and partly because price changes are faster.

These results imply a positive correlation between pass-through and frequency of price adjustments across islands (with different levels of competition). This is consistent with the results of Gopinath and Itskhoki (2010), who find a positive correlation between frequency of price adjustments and magnitude of exchange rate pass-throughs across sectors. Our results are also in line with their theoretical model, in which firms in more competitive markets (i.e., with higher residual demand elasticity) are those with higher frequency of price adjustments and higher pass-throughs.

One might argue that the higher frequency of price adjustments in more competitive islands might be driven by the higher frequency at which these stations are restocked. While we do not have direct evidence on the frequency of restocking, we can study two instances of changes in marginal costs that cannot be possibly affected by the frequency of restocking. In particular, we collected the same data as we used in the main analysis for two changes in VAT (from 19% to

[28] The Kolmogorov-Smirnov test rejects equality of the CDFs at the 1 percent confidence level both for all the excise incidents cumulatively and for each one separately.

21% on 15/3/2010 and from 21% to 23% on 1/7/2010).[29] We compute the frequency of price changes after the VAT changes and plot the cumulative distribution for low and high competition islands in Figure A4 of the appendix. If the results in Figure 6 were driven by the frequency of at which islands are restocked, we would observe no difference in the empirical CDFs for VAT changes. However, Figure A4 provides the same qualitative picture, suggesting that the frequency of restocking is not the driving force behind our previous results.[30]

5.4. Alternative market definitions

Without a clear definition of market boundaries or detailed traffic data (Houde, 2012), the literature has typically defined markets based on the distance between gas stations (Shepard, 1991; Barron, Taylor and Umbeck, 2004; Eckert and West, 2005; Hosken, McMillan and Taylor, 2008; Pennerstorfer et al. 2019). Also, competition authorities throughout the world routinely define markets based on geographical or driving distance between sellers.[31] While realistic, this approach cannot guarantee the absence of substitution effects with firms outside the geographical area considered. In our application, the definition of markets is simpler. Monopoly islands are unambiguously classified as such. In islands with more stations, there can only be substitution effects among firms on the same island. Given the small scale of these islands, some substitution is likely to exist among all stations on the same island.

[29] VAT contributes to the definition of retail prices as described in Section 3. VAT changes affects all products in the same way, so these events do not provide us with a control group. Hence, we do not use these two changes in the main analysis.

[30] The Kolmogorov-Smirnov test rejects equality of the CDFs at the 1 percent confidence level both for all the VAT changes cumulatively and for each one separately.

[31] See, for example, EU Commission Case M.7603 – Statoil Fuel and Retail / Dansk Fuels, and UK Competition and Markets Authority decision ME/6534/15.

We followed standard market definitions and computed for each station the number of competitors within a 3-kilometer radius, 3 and 5-kilometer driving distance, and 10-minute drive (using Google maps).[32] While these three procedures obviously do not affect monopoly islands, they may reduce the number of competitors for stations on larger islands. We then estimate the pass-through using model (2) for stations that have a different number of competitors according to the new market definitions. Table 7 reports the estimated coefficients for the conditional pass-through and Table A10 in the appendix the corresponding coefficients for the average pass-through.

The comparison of the estimated pass through in monopoly islands (first row in Table 7) is particularly telling. In this case, we know that the island market definition (column 1) correctly classifies monopoly islands, which implies that the estimated pass-through is the correct benchmark for evaluating the other market definitions. The fact that the pass-through in columns 2-5 are significantly higher indicates that the alternative distance definitions incorrectly classify some markets as monopolies, ignoring substitution effects across stations, and leading to upward biased coefficients that are 70%, 59%, 60%, or 57% higher. This shows that the distance definition leads to a substantial bias in the estimated pass through.

Table 7 shows that similar results hold for duopolies and triopolies. The pass-through is systematically higher using the distance definitions. For example, the 3Km driving distance definition implies that the pass-through is 64% and 36% higher for markets with two and three firms respectively. This difference becomes negligible in markets with four or more sellers. Given the results obtained for monopoly islands, the most likely explanation for this difference is the

[32] A continuum of possible market definitions exists, but we restricted attention to definitions often used in practice.

existence of substitution effects across sellers on the same island, which are not captured by the distance definitions.

However, we cannot precisely quantify the bias induced by the distance definition for duopolies and triopolies. This is because it is not possible to identify the correct benchmark in this case. For example, the island market definition might incorrectly classify as duopolies some islands on which there are in fact two monopolies (two stations that are sufficiently far not to interact with each other). On the other hand, the distance definition might incorrectly classify as duopolies pairs of gas stations on islands with three or more firms, which are actually competing with each other. Hence, none of the two types of definitions is necessarily correct in this case. Although the distance definition implies an overestimation of the pass through, we cannot interpret the difference in estimated coefficients as a measure of the bias.

Overall, our results suggest that care should be taken when using the standard approach based on distance between sellers, particularly when there is a small number of competitors. This is relevant for academic research and competition policy alike.

6. Concluding Remarks

The paper provides new empirical evidence on the effects of competition on pass-through in clearly defined oligopolistic markets with a small number of firms. We contribute to the growing literature on pass-through by showing that pass-through increases with competition in a nonlinear fashion, growing from 0.4 for monopoly markets to about 1 for markets with four competitors or more. Moreover, the frequency of price adjustments is higher in more competitive markets. This might have important implications for the pass through at the macro level. We also find that conventional definitions of markets that are based on distance between sellers lead to overestimation of the pass-through for markets with up to four competitors. Since these definitions are often used in policy analysis, care should be taken when studying oligopolistic markets.

We acknowledge that the markets for petroleum products on Greek islands are not necessarily representative of oligopolistic markets for other products and on the mainland. We selected this environment precisely because it provides clean variation in competitive environment, which is not typically available for other markets. Hence, the results contribute to our understanding on pass-through by showing new evidence on relationships that may be present in other settings and in larger markets.

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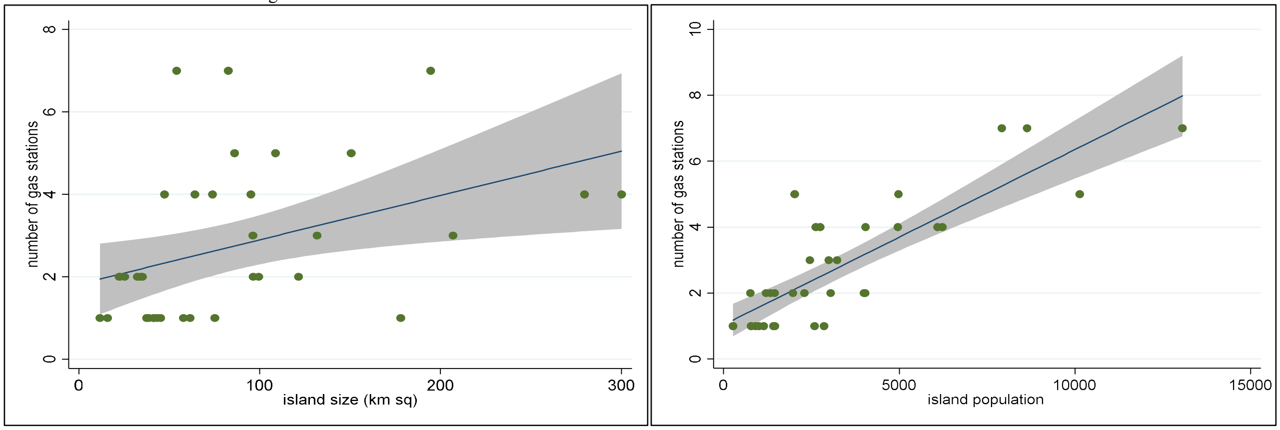
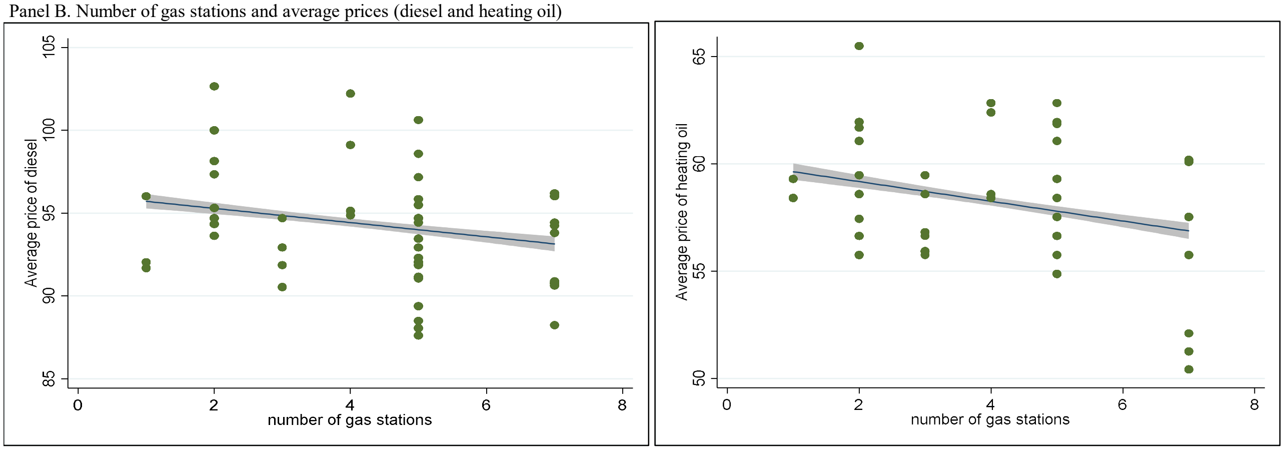
FIGURE 1. COMPETITION AND MARKET SIZE

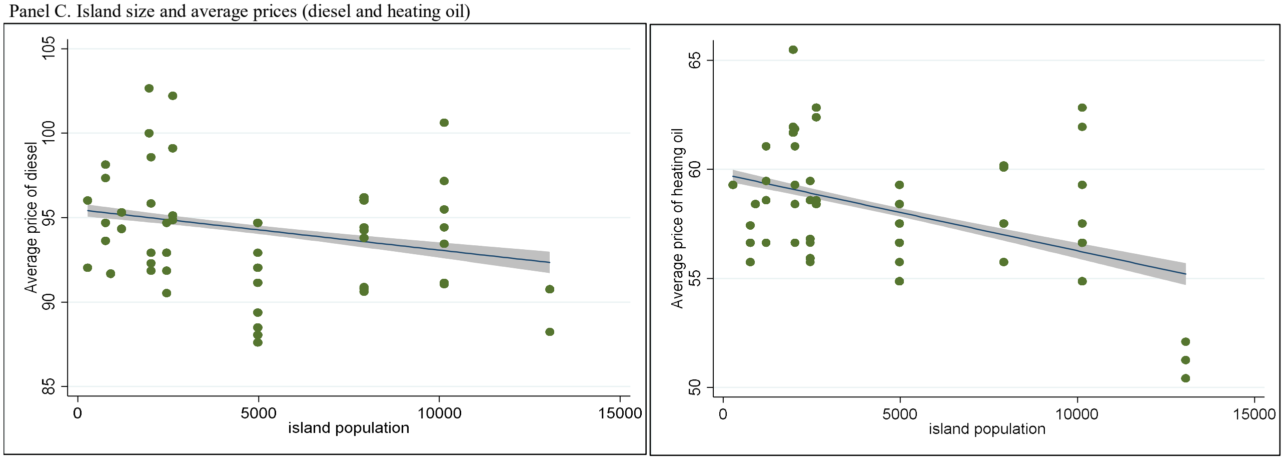
Panel A. Island size and number of gas stations



Panel B. Number of gas stations and average prices (diesel and heating oil)

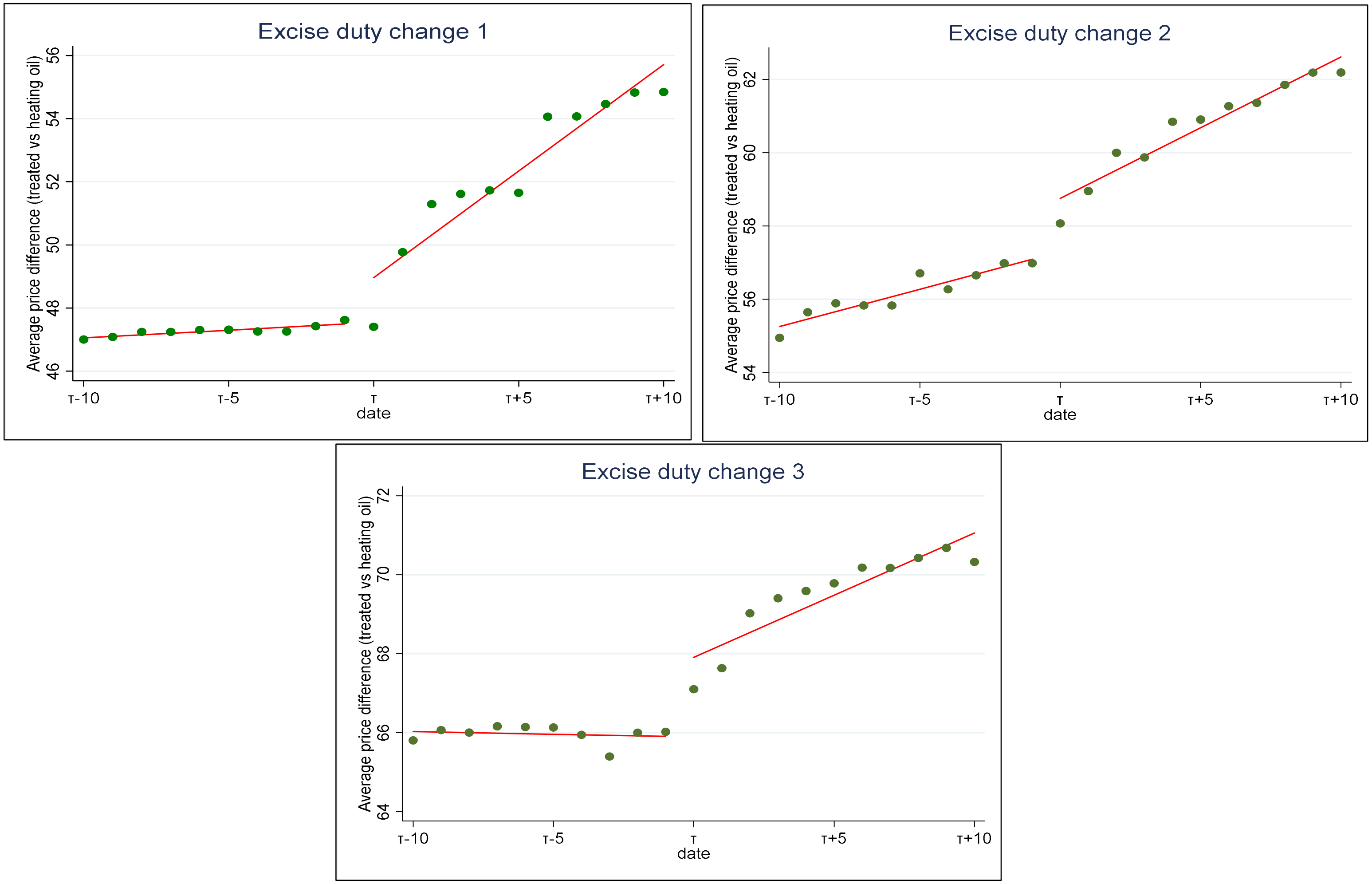


Panel C. Island size and average prices (diesel and heating oil)



Notes: Average values computed in January 2010 (before any excise duty change).
Source: Authors' calculations based on data from the Greek Ministry of Development and the Hellenic Statistical Authority.

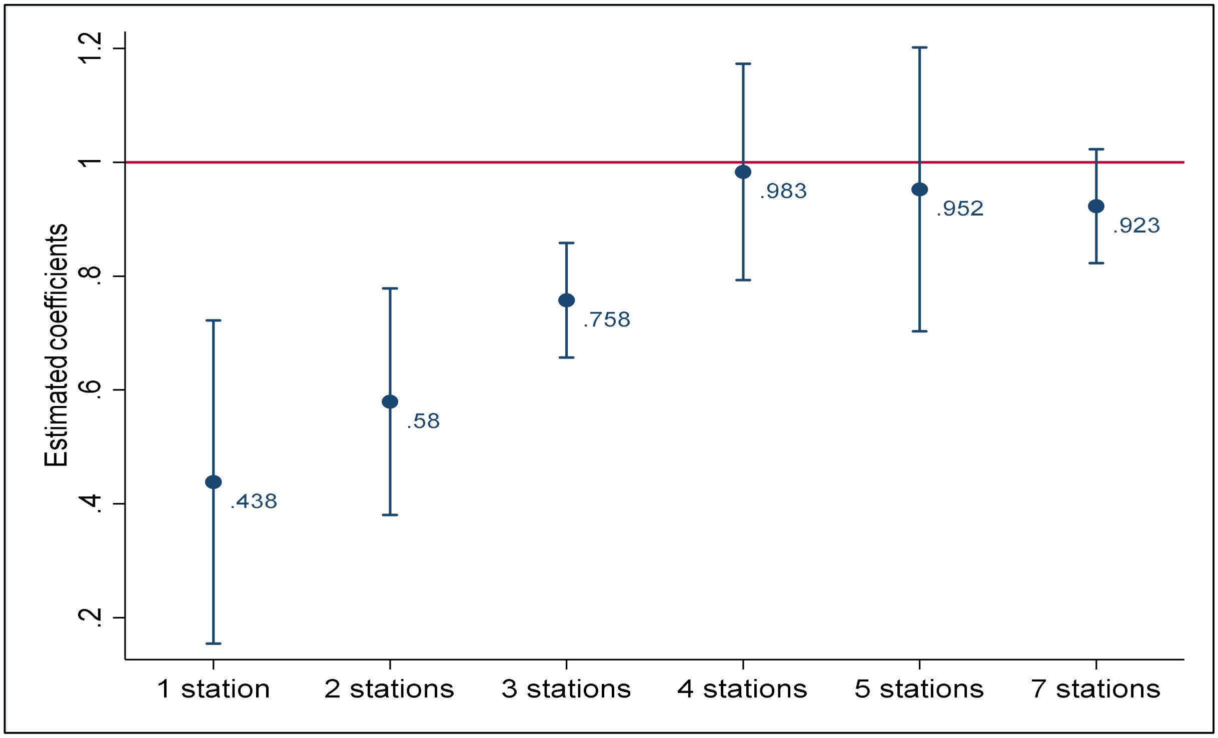
FIGURE 2. AVERAGE PRICE DIFFERENCES BETWEEN TREATED AND CONTROL PRODUCTS



Notes: The three figures plot the average price difference between treated (diesel, unleaded 95, unleaded 100 and super) and control (heating oil) products (for ten days before and after each change in excise duty tax), together with two linear regression lines for the period before and after the tax change. Figure A2 in the Appendix plots similar graphs separately for each product and tax change.
Source: Authors' calculations based on data from the Greek Ministry of Development.

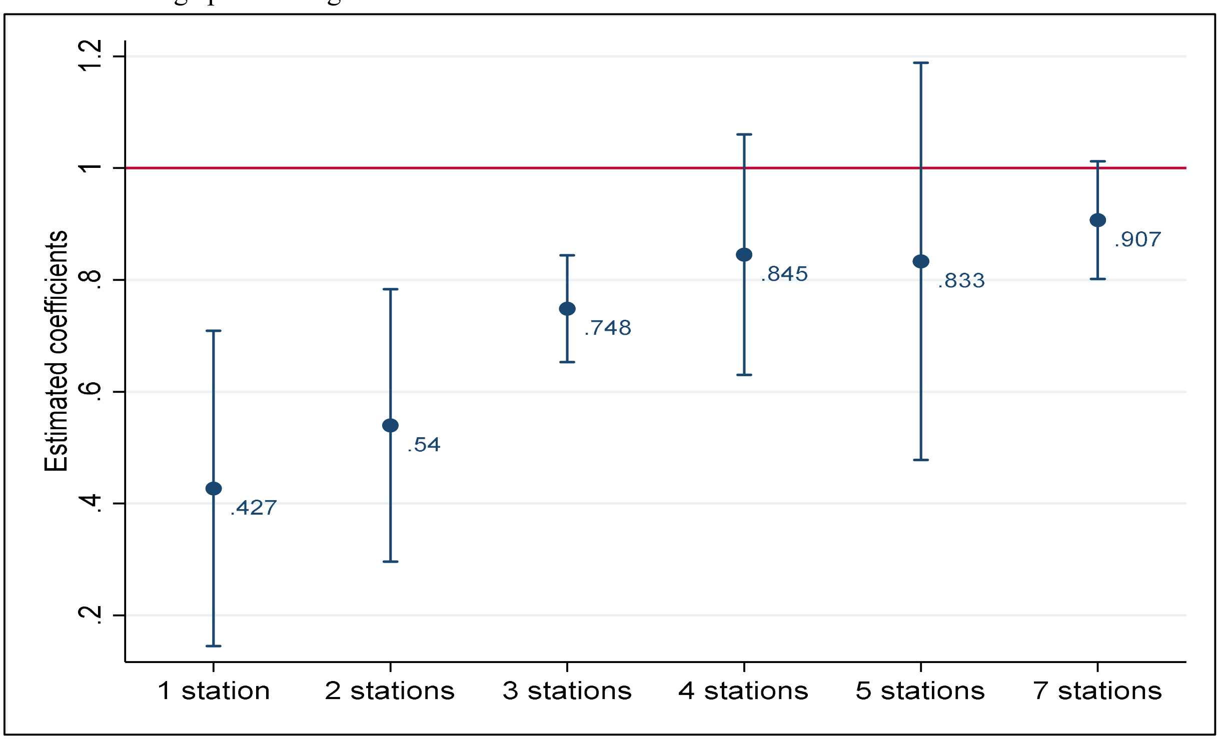
FIGURE 3. PASS-THROUGH AND COMPETITION

Panel A. Conditional pass-through



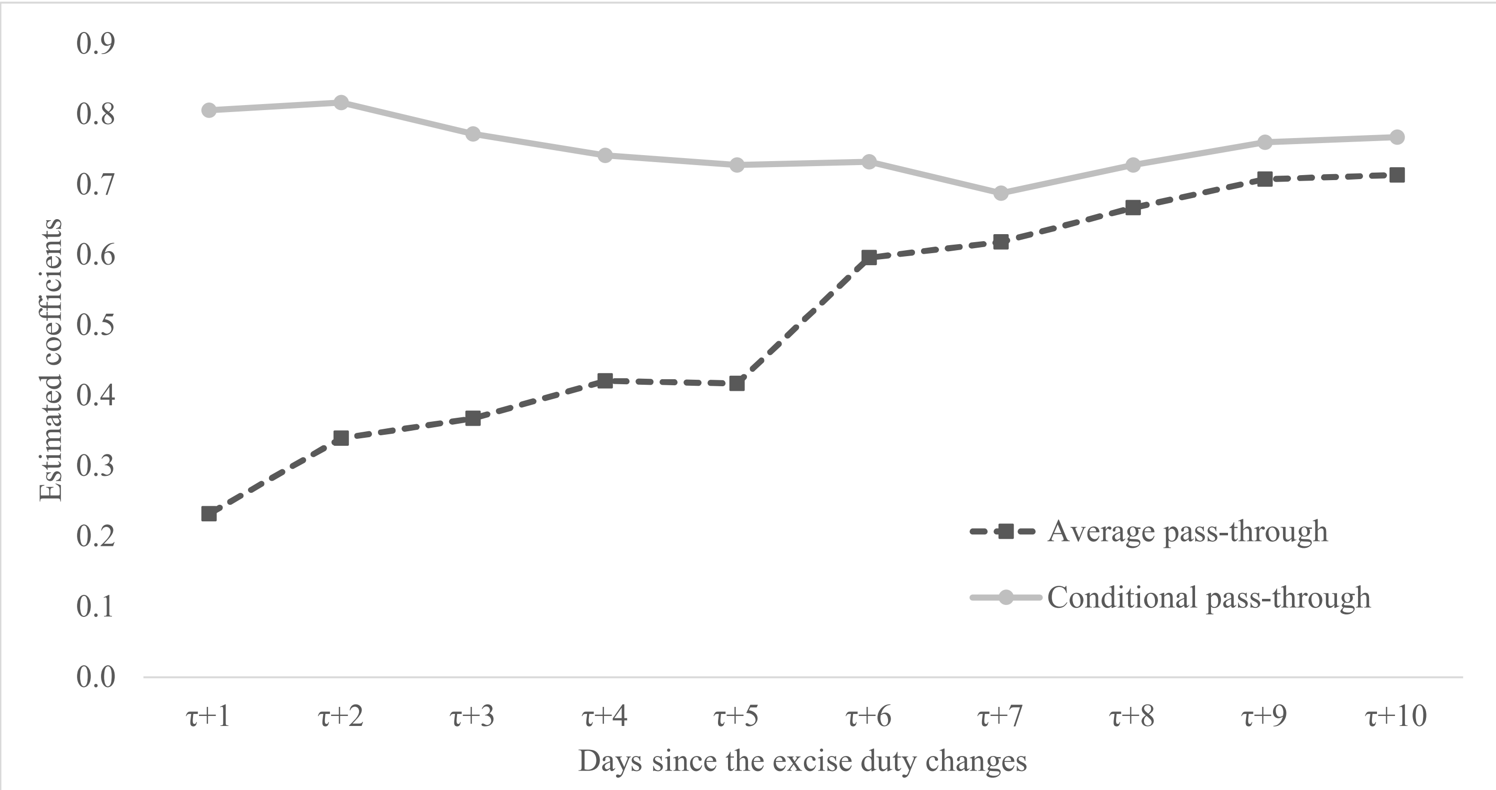
Notes: The figure plots the estimated coefficients from Table 7, column 1, together with the 95% confidence interval.
Source: Authors' calculations based on data from the Greek Ministry of Development.

Panel B. Average pass-through



Notes: The figure plots the estimated coefficients from Table A10, column 1, together with the 95% confidence interval.
Source: Authors' calculations based on data from the Greek Ministry of Development.

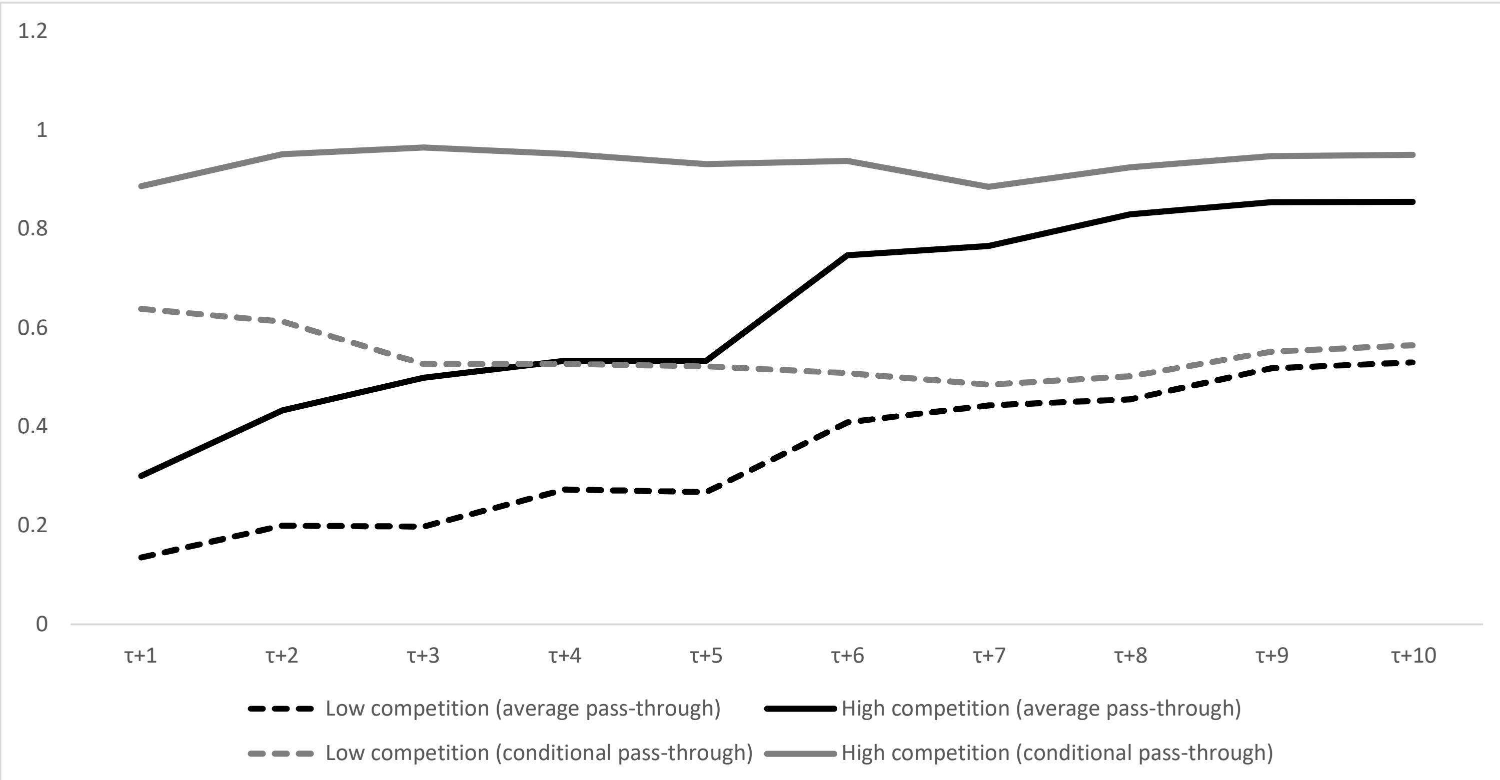
FIGURE 4. PASS-THROUGH AND SPEED OF ADJUSTMENT



Notes: The figure plots the estimated coefficients from Table 5. The average pass-through is estimated using all the data. The conditional pass-through is estimated using observations for station-product combinations that have changed the price at least once between τ and $\tau+\delta$, where τ is the date of the excise duty change and $\delta=1,...,10$.

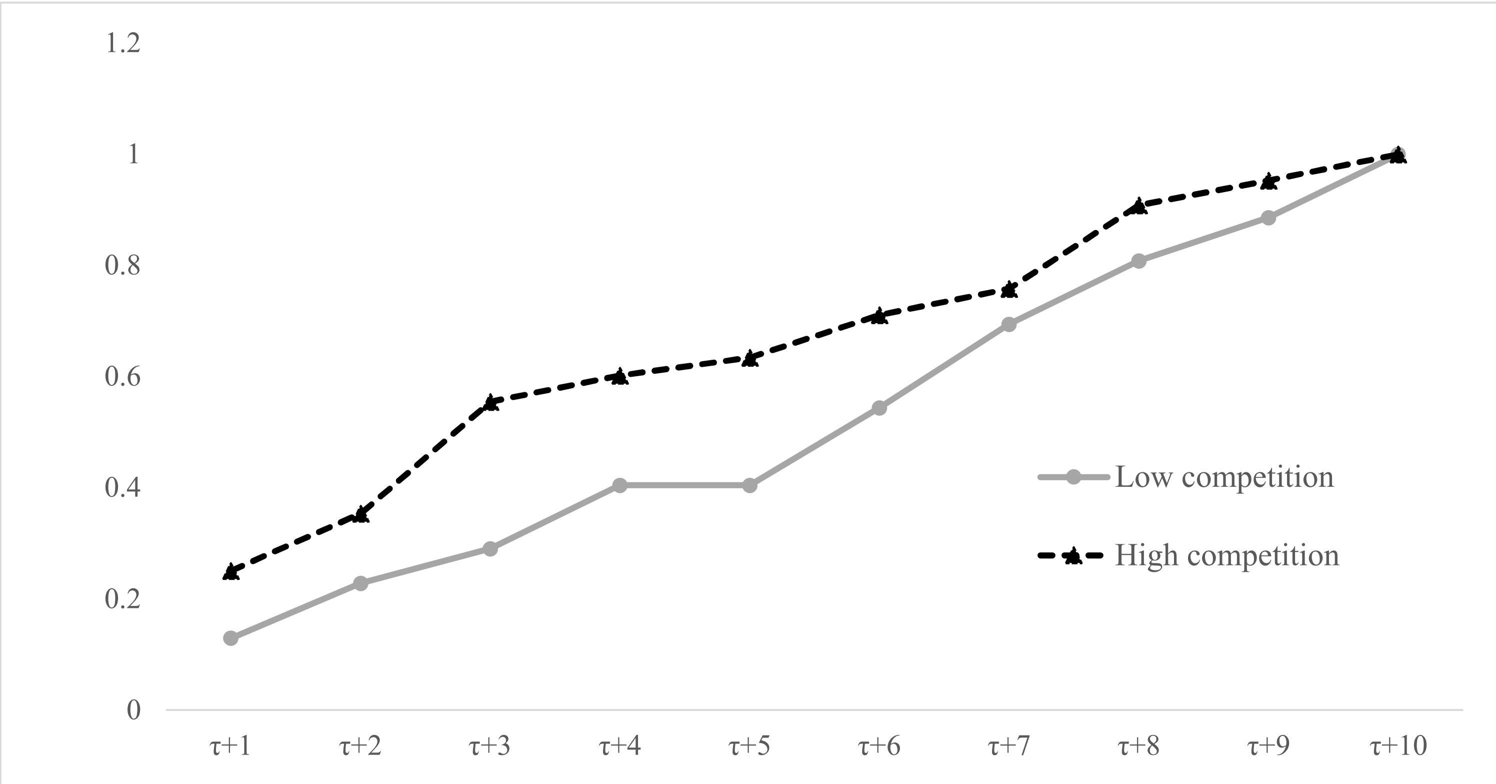
Source: Authors' calculations based on data from the Greek Ministry of Development.

FIGURE 5. SPEED OF ADJUSTMENT AND COMPETITION.



Notes: The figure plots the average and conditional pass-through on islands with 1-3 (low competition) and 4-7 (high competition) gas stations. The average pass-through is estimated using all the data. The conditional pass-through is estimated using observations for station-product combinations that have changed the price at least once between τ and $\tau+\delta$, where τ is the date of the excise duty change and δ=1,...,10. Estimated coefficients are reported in Table 6.
Source: Authors' calculations based on data from the Greek Ministry of Development.

FIGURE 6: CUMULATIVE FREQUENCY OF PRICE CHANGES.



Notes: The figure plots the cumulative frequency of station-product combinations that changed their prices between τ and $\tau+\delta$, where τ is the date of the excise duty change and δ=1,...,10, on islands with 1-3 (low competition) and 4-7 (high competition) gas stations. The Kolmogorov-Smirnov test rejects the equality of the CDFs at the 1 percent confidence level.

TABLE 1 - EXCISE DUTY TAX CHANGES (€ cents per litre and Δ%)

Type of energy product	(1) Unleaded 95	(2) Unleaded 100	(3) Diesel	(4) Super (leaded)	(5) Heating oil
before	41	41	30.2	42.1	2.1
10-Feb-10	53	53	35.2	54.1	2.1
	(29%)	(29%)	(17%)	(29%)	(0%)
04-Mar-10	61	61	38.2	62.1	2.1
	(15%)	(15%)	(9%)	(15%)	(0%)
03-May-10	67	67	41.2	68.1	2.1
	(10%)	(10%)	(8%)	(10%)	(0%)

Notes: The table reports the level and percentage changes in excise duties by product.
Source: Authors' calculations based on data from the Eurostat (rates and structure of excise duties for energy products).

TABLE 2 - SUMMARY STATISTICS

Variable	Mean	Standard Deviation	Median	10th percentile	90th percentile
PANEL A - PRICES (N=10,129)					
Unleaded 95 (€ cents per litre)	126	12.4	125	107	142
Unleaded 100 (€ cents per litre)	136	12.7	136	119	152
Super (€ cents per litre)	127	12.5	125	110	143
Diesel (€ cents per litre)	107	8.5	106	96	118
Heating oil (€ cents per litre)	62	4.1	62	57	67
PANEL B - ISLAND CHARACTERISTICS (N=33)					
Size (Km^2)	91	72	74	25	195
Population (number of inhabitants)	3,375	3,009	2,590	765	7,917
Ports	2	1	1	1	3
Airports	0.2	0.4	0.0	0.0	1.0
Arrivals (number of tourists)	120,069	173,642	60,785	15,411	296,016
Distance from Piraeus (Km)	117	59	105	45	205
Income (€)	17,881	1,874	17,257	15,604	20,471
Education (tertiary, % population)	11%	2%	10%	9%	13%

Notes: Island socioeconomic and geographic characteristics were obtained from the Hellenic Statistical Authority (Census 2010). Arrivals refer to tourist arrivals by air or sea in 2010. Income per capita based on a release from the Independent Authority of Public Revenue.
Source: Authors' calculations based on data from the Greek Ministry of Development and the Hellenic Statistical Authority.

TABLE 3 - EXCISE DUTY PASS-THROUGH.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Pass-through definition	Conditional	Conditional	Conditional	Conditional	Average	Average	Average	Average
Dependent variable	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$
Sample	Excise change 1	Excise change 2	Excise change 3	All excise changes	Excise change 1	Excise change 2	Excise change 3	All excise changes
Tax_{kt}	0.690	1.076	0.661	0.767	0.654	0.918	0.634	0.713
	(0.131)	(0.101)	(0.106)	(0.099)	(0.129)	(0.122)	(0.112)	(0.103)
Observations	283	261	335	879	295	299	351	945
Within R^2	0.743	0.757	0.662	0.931	0.712	0.658	0.641	0.926
Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Product × Station FE	yes	yes	yes	yes	yes	yes	yes	yes
Excise change × Product type FE				yes				yes
Excise change × Station FE				yes				yes

Notes: The dependent variable is the retail price of product *k*, on island *i* , in gas station *s*, and day $t \in \{\tau - 1, \tau + 10\}$, where τ is the date of each of the three excise duty changes. The pass-through is estimated using observations for station-product combinations that have changed the price at least once between τ and τ+10 in columns 1-4 (conditional pass-through), or all the available data in columns 5-8 (average pass-through). Standard errors clustered at the island level are reported in parentheses below coefficients.
Source: Authors' calculations based on data from the Greek Ministry of Development and Eurostat.

TABLE 4 - PASS-THROUGH AND COMPETITION.

	(1)	(2)	(3)	(4)	(5)	(6)
Estimation method	FE	FE	IV	FE	FE	IV
Dependent variable	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$
Sample	All excise changes	All excise changes	All excise changes	All excise changes	All excise changes	All excise changes
	PANEL A: CONDITIONAL PASS-THROUGH					
Tax_{it}	0.449	-0.736	0.464	0.139	-0.601	-0.702
	(0.103)	(1.095)	(0.109)	(0.208)	(0.930)	(0.535)
Tax_{it} × Number of $competitors_s$	0.086	0.082	0.082	0.289	0.265	0.821
	(0.024)	(0.033)	(0.023)	(0.112)	(0.135)	(0.348)
Tax_{it} × Number of $competitors_s^2$				-0.025	-0.023	-0.090
				(0.012)	(0.015)	(0.044)
First stage F-test (Number of competitors)			21.86			36.53
First stage F-test (Number of $competitors^2$)						13.21
Within R^2	0.937	0.939		0.939	0.940	
Observations	879	879	879	879	879	879
	PANEL B: AVERAGE PASS-THROUGH					
Tax_{it}	0.409	-0.599	0.403	0.233	-0.561	-0.948
	(0.109)	(1.107)	(0.129)	(0.228)	(1.065)	(0.865)
Tax_{it} × Number of $competitors_s$	0.082	0.068	0.083	0.195	0.110	0.930
	(0.023)	(0.036)	(0.024)	(0.132)	(0.158)	(0.566)
Tax_{it} × Number of $competitors_s^2$				-0.014	-0.005	-0.104
				(0.014)	(0.018)	(0.073)
First stage F-test (Number of competitors)			18.00			30.66
First stage F-test (Number of $competitors^2$)						11.34
Within R^2	0.931	0.934		0.931	0.934	
Observations	945	945	945	945	945	945
Time FE	yes	yes	yes	yes	yes	yes
Product × Station FE	yes	yes	yes	yes	yes	yes
Excise change × Product type FE	yes	yes	yes	yes	yes	yes
Excise change × Station FE	yes	yes	yes	yes	yes	yes
Additional controls (interactions with income, education, number of ports, and airports, distance from Piraeus and tourist arrivals).		yes			yes	

Notes: The dependent variable is the retail price of product *k*, on island *i*, in gas station s, and day $t\in\{\tau-1, \tau+10\}$, where τ is the date of each of the three excise duty changes. In Panel A the pass-through is estimated using observations for station-product combinations that have changed the price at least once between τ and $\tau+10$ (conditional pass-through), whereas in Panel B we use all available data (average pass-through). Standard errors clustered at the island level are reported in parentheses below coefficients. First stage results for columns 3 and 6 are reported in Table A9 of the Appendix.
Source: Authors' calculations based on data from the Greek Ministry of Development, the Hellenic Statistical Authority and Eurostat.

TABLE 5 - SPEED OF ADJUSTMENT

	(1)	(2)
Dependent variable	$Price_{kist}$	$Price_{kist}$
Sample	All excise changes	All excise changes
Pass-through definition	Average	Conditional
Tax_{it}	0.232	0.805
(τ-1, τ+1)	(0.111)	(0.134)
Tax_{it}	0.339	0.816
(τ-1, τ+2)	(0.101)	(0.129)
Tax_{it}	0.368	0.771
(τ-1, τ+3)	(0.099)	(0.120)
Tax_{it}	0.421	0.741
(τ-1, τ+4)	(0.091)	(0.109)
Tax_{it}	0.417	0.727
(τ-1, τ+5)	(0.091)	(0.109)
Tax_{it}	0.596	0.732
(τ-1, τ+6)	(0.114)	(0.111)
Tax_{it}	0.618	0.687
(τ-1, τ+7)	(0.118)	(0.110)
Tax_{it}	0.667	0.727
(τ-1, τ+8)	(0.117)	(0.113)
Tax_{it}	0.707	0.759
(τ-1, τ+9)	(0.105)	(0.102)
Tax_{it}	0.713	0.767
(τ-1, τ+10)	(0.103)	(0.099)

Notes: Each coefficient comes from a separate regression. The dependent variable is the retail price of product k, on island i, in gas station s, and day $t \in \{\tau-1, \tau+\delta\}$, where τ is the date of each of the three excise duty changes and δ=1,…,10 is the adjustment period. The fixed effects are the same as in Table 3, columns 4 and 8. The average pass-through (column 1) is estimated using all the data. The conditional pass-through (column 2) is estimated using observations for station-product combinations that have changed the price at least once between τ and $\tau+\delta$. Standard errors clustered at the island level are reported in parentheses below coefficients.
Source: Authors' calculations based on data from the Greek Ministry of Development and Eurostat.

TABLE 6 - SPEED OF ADJUSTMENT AND COMPETITION

PANEL A. AVERAGE PASS-THROUGH

	(1)	(2)	(3)	(4)	(5)
Dependent variable	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$
Sample	All excise changes	All excise changes	All excise changes	All excise changes	All excise changes
	(τ-1, τ+1)	(τ-1, τ+2)	(τ-1, τ+3)	(τ-1, τ+4)	(τ-1, τ+5)
Tax_{it} × Low competition	0.136	0.200	0.198	0.273	0.268
(1-3 competitors)	(0.074)	(0.082)	(0.078)	(0.065)	(0.065)
Tax_{it} × High competition	0.301	0.433	0.500	0.534	0.534
(4-7 competitors)	(0.152)	(0.129)	(0.118)	(0.111)	(0.111)
Test equality of coefficients (p-value)	*0.230*	*0.060*	*0.009*	*0.011*	*0.010*

PANEL A (CONTINUED). AVERAGE PASS-THROUGH

	(6)	(7)	(8)	(9)	(10)
Dependent variable	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$
Sample	All excise changes	All excise changes	All excise changes	All excise changes	All excise changes
	(τ-1, τ+6)	(τ-1, τ+7)	(τ-1, τ+8)	(τ-1, τ+9)	(τ-1, τ+10)
Tax_{it} × Low competition	0.410	0.443	0.456	0.519	0.531
(1-3 competitors)	(0.105)	(0.104)	(0.103)	(0.094)	(0.092)
Tax_{it} × High competition	0.747	0.766	0.831	0.855	0.856
(4-7 competitors)	(0.125)	(0.135)	(0.118)	(0.107)	(0.107)
Test equality of coefficients (p-value)	*0.014*	*0.021*	*0.006*	*0.008*	*0.011*

PANEL B. CONDITIONAL PASS-THROUGH

	(1)	(2)	(3)	(4)	(5)
Dependent variable	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$
Sample	All excise changes	All excise changes	All excise changes	All excise changes	All excise changes
	(τ-1, τ+1)	(τ-1, τ+2)	(τ-1, τ+3)	(τ-1, τ+4)	(τ-1, τ+5)
Tax_{it} × Low competition	0.639	0.614	0.528	0.528	0.523
(1-3 competitors)	(0.110)	(0.092)	(0.078)	(0.072)	(0.072)
Tax_{it} × High competition	0.888	0.952	0.966	0.953	0.932
(4-7 competitors)	(0.120)	(0.082)	(0.058)	(0.060)	(0.067)
Test equality of coefficients (p-value)	*0.063*	*0.000*	*0.000*	*0.000*	*0.000*

PANEL B (CONTINUED). CONDITIONAL PASS-THROUGH

	(6)	(7)	(8)	(9)	(10)
Dependent variable	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$	$Price_{ist}$
Sample	All excise changes	All excise changes	All excise changes	All excise changes	All excise changes
	(τ-1, τ+6)	(τ-1, τ+7)	(τ-1, τ+8)	(τ-1, τ+9)	(τ-1, τ+10)
Tax_{it} × Low competition	0.509	0.486	0.502	0.552	0.565
(1-3 competitors)	(0.105)	(0.096)	(0.093)	(0.085)	(0.082)
Tax_{it} × High competition	0.939	0.886	0.926	0.948	0.951
(4-7 competitors)	(0.091)	(0.095)	(0.089)	(0.076)	(0.076)
Test equality of coefficients (p-value)	*0.001*	*0.001*	*0.001*	*0.000*	*0.001*

Notes: The dependent variable is the retail price of product *k*, on island *i*, in gas station s, and day $t \in \{\tau-1, \tau+\delta\}$, where τ is the date of each of the three excise duty changes and δ=1,…,10. The average pass-through is estimated using all the data. The conditional pass-through is estimated using observations for station-product combinations that have changed the price at least once between τ and $\tau+\delta$. Standard errors clustered at the island level are reported in parentheses below coefficients. The p-value of the test of equality of each set of coefficients is reported in italics in the last row of each panel.
Source: Authors' calculations based on data from the Greek Ministry of Development and Eurostat.

TABLE 7 - CONDITIONAL PASS-THROUGH AND COMPETITION: ALTERNATIVE MARKET DEFINITIONS

	(1)	(2)	(3)	(4)	(5)
Dependent variable	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$	$Price_{kist}$
Market definition	Island	3 Km driving distance	3 Km radius	10 min driving distance	5 Km driving distance
Tax_{it} × One competitor	0.438	0.748	0.695	0.701	0.688
	(0.137)	(0.105)	(0.084)	(0.093)	(0.085)
Tax_{it} × Two competitors	0.580	0.951	1.046	0.915	0.972
	(0.096)	(0.060)	(0.053)	(0.089)	(0.093)
Tax_{it} × Three competitors	0.758	1.034	0.968	0.875	0.890
	(0.048)	(0.115)	(0.089)	(0.067)	(0.060)
Tax_{it} × Four competitors	0.983	1.020	1.034	0.963	1.009
	(0.092)	(0.118)	(0.098)	(0.146)	(0.115)
Tax_{it} × Five competitors	0.952	0.829	0.895	0.916	0.922
	(0.120)	(0.059)	(0.072)	(0.065)	(0.061)
Tax_{it} × Six competitors				0.794	0.814
				(0.065)	(0.059)
Tax_{it} × Seven competitors	0.923				
	(0.048)				
Observations	879	609	609	499	537
Within R^2	0.939	0.966	0.967	0.964	0.964
Time FE	yes	yes	yes	yes	yes
Product × Station FE	yes	yes	yes	yes	yes
Excise incident × Product type FE	yes	yes	yes	yes	yes
Excise incident × Station FE	yes	yes	yes	yes	yes

Notes: The dependent variable is the retail price of product *k*, on island i, in gas station s, and day $t \in \{\tau-1, \tau+10\}$, where τ is the date of each of the three excise duty changes. The pass-through is estimated using observations for station-product combinations that have changed the price at least once between τ and τ+10 (conditional pass-through). Standard errors clustered at the island level are reported in parentheses below coefficients. Table A10 in the Appendix reports the results for the average pass-through.
Source: Authors' calculations based on data from the Greek Ministry of Development, the Hellenic Statistical Authority, Eurostat and Google Maps.